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(54) **SHORT CHAIN DIESTERS AND PROCESS FOR THEIR PRODUCTION**

(57) A process to obtain a product having a high content of zeaxanthin, lutein or mixtures thereof, as short chain organic acid diesters of zeaxanthin, lutein or mixtures thereof, that can be used mainly for the pigmentation of broilers and egg yolks, as well as an intermediate in the cantaxanthin ( $\beta,\beta$ -Carotene-4,4'-dione) and astaxanthin (3,3'-Dihydroxy  $\beta,\beta$ -carotene,4,4'-dione) synthesis, by reacting extracts obtained from marigold (*Tagetes Erecta* L.), or plant extracts that contain lutein, zeaxanthin or mixtures thereof in any proportion, with acetic or propionic anhydride under controlled conditions of temperature and pressure.

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**Description****BACKGROUND OF THE INVENTION**5 **A. FIELD OF THE INVENTION**

**[0001]** This invention is related to short chain diesters, and more particularly to a process for the obtain a product with a high content of zeaxanthin, lutein or mixtures thereof, as short chain organic acid diesters of zeaxanthine, lutein or mixtures thereof.

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**B. DESCRIPTION OF THE RELATED ART.**

**[0002]** The yellow carotenoids such as the lutein and the zeaxanthin, occur in marigold flowers as mono- or diesters, linked to long chain fatty adds such as palmitic, stearic or myristic acids, among others (Alam, A. U. (1968) *Lipids*, 3(2), 183; Gayle G. (1986) *J. Food Sci.*, 51(4), 1093).

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**[0003]** It is assumed that in such chemical structure, the carotenoids are better protected against oxidative processes, so that the flower color is better preserved in nature.

**[0004]** However, in the pigmentation of broilers, it has been shown that the bioavailability of such carotenoid fatty esters is lower than when they are hydrolized, i.e. when they are fed as free carotenoids (Coon, C.N. (1976) *Poult. Sci.*, 55, 841-847).

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**[0005]** Applicant's have found that by saponification of the marigold carotenoids and their subsequent linking to short chain organic acids, such as formic, acetic propionic, etc., an improvement in their bioavailability, and that a more stable form of the carotenoids is achieved.

**[0006]** The acetylation of carotenoids, zeaxanthin among others, has been carried out in laboratory scale since decades ago. The reported methodology specifically refers to a research, for elucidation purposes about the chemical structures of the carotenoids.

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**[0007]** The carotenoid in pure form, zeaxanthin in this case, is dissolved in pyridine treating it with acetic anhydride and agitation at room temperature to obtain the acetylated derivative after several hours (Liaaen-Jensen, S. and Jensen, A. (1971) *Methods Enzymol.* 23, 586), or in a few minutes if the reactants mixture is maintained under reflux (Alam, 1968).

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**[0008]** Another preferred chemical path to obtain the acetylated compound is to dissolve the zeaxanthin in pyridine and benzene to carry on the reaction at 20° C with acetyl chloride, a few minutes later (Bartlett, L. (1969) *J. Chem. Soc. C*, 2538).

**[0009]** In the process according with the present invention, marigold extracts containing saponified and isomerized carotenoids (Torres, et al. 5,523,494 6/1996, 568/834), are treated directly with acetic anhydride, or propionic anhydride in such a way as to obtain the short chain organic acid diester derivatives of zeaxanthin, lutein or mixtures thereof, present in such extracts.

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**SUMMARY OF THE INVENTION**

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**[0010]** It is a main objective of the present invention to provide a product having a high content of zeaxanthin, lutein or mixtures thereof, in the form of short chain organic acid diesters of zeaxanthin, lutein or mixtures thereof, which can be used mainly in the pigmentation of broilers skin and egg yolks.

**[0011]** It is an additional main objective of the present invention to provide a process to obtain a product with a high content of zeaxanthin, lutein or mixtures thereof, in the form of short chain organic acid diesters of zeaxanthin, lutein or mixtures thereof which can be used mainly in the pigmentation of broilers skin and egg yolks.

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**[0012]** It is still a main objective of the present invention to provide a process at the above disclosed nature, by reacting short chain organic anhydrides to saponified extracts containing carotenoids, in an inert atmosphere of carbon dioxide, nitrogen or a mixture of born under controlled conditions of temperature and pressure.

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**[0013]** It is another main objective of the present invention to provide a process of the above disclosed nature in which saponified extracts containing carotenoids are treated without the need to add of any solvent at all.

**[0014]** It is still another main objective of the present invention, to provide a process of the above disclosed nature, wherein the product or its formulations can be used for the pigmentation of broiler skin and egg yolk or as a pigmenting agent in aquaculture.

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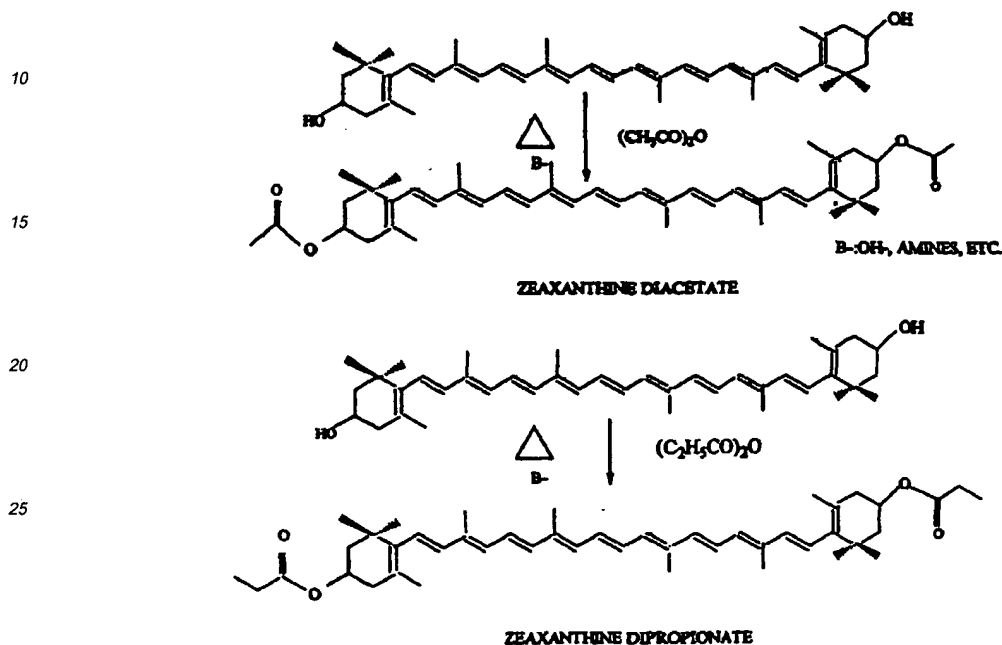
**[0015]** It is also an additional object of the present invention to provide a process of the above disclosed nature wherein the zeaxanthin diester obtained can be used as an intermediate in the synthesis of astaxanthin or cantaxanthin.

**[0016]** These and other objectives and advantages of the present invention will be apparent to those persons hav-

ing ordinary skill in the art, from the following detailed description of the invention.

# DETAILED DESCRIPTION OF THE INVENTION

5 [0017] The chemical process is carried out according to the following reaction:



[0018] The saponified marigold extract containing the zeaxanthin, has been obtained according to the procedure reported by Torres, et al. (1996), but any pigmenting formulation or extract containing zeaxanthin can be used. Regardless of the raw material employed, it should preferably be moisture free before acetylating with acetic anhydride, or before treatment with propionic anhydride.

[0019] The carotenoid containing substrate is maintained at a temperature in the range of 25°C to 140°C, but preferably between 40°C and 100°C.

[0020] When a crude marigold extract containing the saponified and isomerized carotenoids, enters into the reaction with the acetic or propionic anhydride, its residual fatty acids and other lipids present occur as the sodium or potassium salts.

## Acetylation reaction

45 [0021] The acetic anhydride is slowly added to the extract in a reaction vessel under agitation, in a proportion from 0.2 to 2.0 parts by weight for one part of the pigmenting concentrate, which is in the form of a sodium or potassium soap (a heavy paste highly soluble in water). The reaction mixture is partially soluble in the acetic anhydride. However, as the acetylation reaction advances, an oily phase separates from the reaction media, mainly composed of acetic acid and sodium or potassium acetates in aqueous solution, from which it easily separated by decanting. The acetylation vessel

50 wherein the reaction takes place should be kept under an inert atmosphere, in order to avoid the intensive degradation of the xanthophylls. An inert diluent such as ethylene glycol or propylene glycol or an aliphatic or cyclic hydrocarbon can be used to reduce the viscosity of the mixture.

[0022] The reaction time depends on the temperature and can be from 6 minutes to 24 hours, but preferably from 4 to 18 hours.

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| Parameter                       | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---------------------------------|---------|---------|---------|---------|
| Acetic anhydride: extract Ratio | 0.5     | 2.5     | 1.0     | 2.0     |
| Reaction time, hrs.             | 16      | 16      | 20      | 12      |
| Reaction temperature, °C        | 90      | 80      | 100     | 60      |
| Pressure, mm Hg                 | 750     | 760     | 750     | 760     |
| Mono-hydroxycarotenoids %       | 4.2     | 1.5     | 1.7     | 2.8     |
| Di-hydroxycarotenoids %         | 2.1     | 1.3     | 1.3     | 0.8     |
| Aceto-carotenoids %             | 88.5    | 91.8    | 89.6    | 90.2    |

#### Propionation reaction

**[0023]** Propionic anhydride is slowly added to the extract in a reaction vessel under agitation, in a proportion from 0.2 to 3.0 parts by weight to one part of the pigmenting concentrate, which is in the form of sodium or potassium soap (a heavy paste highly soluble in water). The reaction mix is partially soluble in the propionic anhydride. However as the propionation reaction advances, an oily phase separates from the reaction media, mainly composed of propionic acid and sodium or potassium propionates in aqueous solution, from which it is easily separated by decanting. The reaction vessel should be kept under an inert atmosphere to avoid degradation.

**[0024]** The reaction time depends on the temperature and can be from 5 minutes to 24 hours, but preferably from 3 to 17 hours.

| Parameter                         | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|-----------------------------------|---------|---------|---------|---------|
| Propionic Anhydride:extract Ratio | 0.8     | 2.5     | 2.0     | 3.0     |
| Reaction time, hrs.               | 6       | 4       | 4       | 3       |
| Reaction temperature, °C          | 70      | 60      | 80      | 80      |
| Pressure, mm Hg.                  | 760     | 780     | 760     | 750     |
| Mono-hydroxycarotenoids %         | 4.1     | 1.5     | 1.8     | 0.7     |
| Di-hydroxycarotenoids %           | 2.3     | 1.0     | 0.6     | 1.0     |
| Propionate-carotenoids            | 86.0    | 90.0    | 89.0    | 91.0    |

**[0025]** The saponified extracts used as the raw material in the above described process, contain approximately 92 % of di-hydroxy carotenoids, and 1-2% of mono-hydroxy carotenoids, quantified according to the AOAC method.

**[0026]** The identification and quantification of the pigments involved were carried out following the HPLC techniques mentioned by Torres, et al. (1996), as well as by the use of other spectroscopic techniques as IR, UV, <sup>1</sup>HNMR, etc., widely used in carotenoids identification.

**[0027]** The end product can be formulated as an aqueous emulsion, or it can be dispersed by means of a carrier to obtain pre-mixtures of a given concentration of zeaxanthin, lutein or mixtures thereof in the form of short chain organic acid diesters, to be used as a pigmenting agent for broiler's skin, egg yolks, or shrimps and salmon in aquaculture.

#### Claims

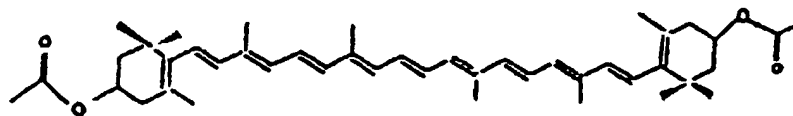
1. A process for the obtention of short chain organic acid diesters of mono-or polyhydroxylated carotenoids, from saponified extracts containing carotenoids, comprising: reacting short chain organic anhydrides, slowly under agitation, to said saponified extracts containing carotenoids, under controlled conditions of temperature and pressure.
2. The process as claimed in claim 1, wherein the carotenoids are selected from the group consisting in yellow caro-

tenoids, lutein or zeaxanthin.

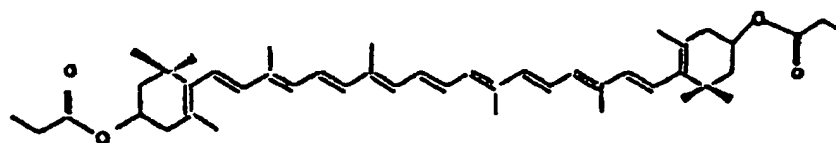
3. The process as claimed in claim 1, wherein saponified extracts containing carotenoids are obtained from extracts of marigold flowers, marigold meal, yellow corn, yellow corn gluten, or alfalfa.
- 5 4. The process as claimed in claim 1, wherein the zeaxanthin is in its free hydrolyzed form.
5. The process as claimed in claim 1, wherein the lutein or any other hydroxycarotenoid or mixtures thereof are hydrolyzed.
- 10 6. The process as claimed in claim 1, wherein the short chain organic anhydrides are selected from the group consisting of acetic anhydride or propionic anhydride.
7. The process as claimed in claim 1, wherein the proportion of acetic anhydride is from 0.2 to 2.0 parts by weight, preferably from 0.5 to 1.5 parts by weight, for one part of extract.
- 15 8. The process as claimed in claim 1, wherein the proportion of propionic anhydride is from 0.5 to 3.5 parts, preferably from .5 to 1.5 parts by weight for one part of extract.
- 20 9. The process as claimed in claim 1, wherein the saponified extract is preferably moisture free.
10. The process as claimed in claim 1, wherein the saponified extract is from an alkaline reaction, containing residual NaOH, KOH or a mixture of both, or any other alkaline or alkaline-earthen metal hydroxides, as well as organic basis such as the morpholine, ethylamine, diethylamine, ethanolamine and the like.
- 25 11. The process as claimed in claim 1, wherein the reaction is carried out in the presence of ethylene glycol or propylene glycol in order to reduce the viscosity of the mixture.
12. The process as claimed in claim 1, wherein the reaction is carried out in the presence of an aliphatic or a cyclic hydrocarbon or an organic solvent to reduce the viscosity of the mixture.
- 30 13. The process as claimed in claim 1, wherein the acetic anhydride can be mixed in any proportion with metallic salts of acetic acid, preferably with sodium or potassium salts.
- 35 14. The process as claimed in claim 1, wherein the propionic anhydride can be mixed in any proportion with metallic propionates, preferably with sodium or potassium salts.
15. The process as claimed in claim 1, wherein the reaction time is from 5 minutes to 12 hours, preferably from 2 to 10 hours.
- 40 16. The process as claimed in claim 1, wherein the reaction temperature is from 25°C to 140°C, preferably from 40°C to 100°C.
17. The process as claimed in claim 1, wherein the reaction is carried out in an inert atmosphere of carbon dioxide, nitrogen, or a mixture of both.
- 45 18. The process as claimed in claim 1, wherein the reaction product contains from 5% to 90% of zeaxanthin diacetate.
19. The process as claimed in claim 1, wherein the reaction product contains from 5% to 90% of zeaxanthin di-propionate.
- 50 20. The process as claimed in claim 1, wherein the product or its formulations can be used for the pigmentation of broilers skin and egg yolks or as a pigments agent in aquaculture.
- 55 21. The process as claimed in claim 1 wherein the zeaxanthin diester obtained can be used as an intermediate in the synthesis of astaxanthin.
22. The process as claimed in claim 1 wherein the zeaxanthin diester obtained can be used as an intermediate in the

synthesis of cantaxanthin.

23. Short chain organic acid diesters of mono- or polyhydroxylated carotenoids, of the formula:



**ZEAXANTHIN DIACETATE; OR**



**ZEAXANTHIN DIPROPIONATE**

24. The short chain organic acid diesters, as claimed in claim 23, containing from 5% to 90% of zeaxanthin diacetate.

25. The short chain organic acid diesters, as claimed in claim 23, containing from 5% to 90% of zeaxanthin di-propionate.

26. Short chain organic acid diesters of mono- or polyhydroxylated carotenoids, obtained by reacting short chain organic anhydrides, slowly under agitation, to saponified extracts containing carotenoids, under controlled conditions of temperature and pressure.

27. The short chain organic acid diesters as claimed in claim 26, wherein the short chain organic anhydrides are selected from the group consisting of acetic anhydride or propionic anhydride.

## INTERNATIONAL SEARCH REPORT

International application-No.

PST/MX 98/00052

| <b>A. CLASSIFICATION OF SUBJECT MATTER</b>  |   |  |
|---|---|--|
| CIP <sup>6</sup> C07C 67/08, 35/08; C09B 61/00; A23L 1/275; A23K 1/16, 1/18   |   |  |
| According to International Patent Classification (IPC) or to both national classification and IPC   |   |  |
| <b>B. FIELDS SEARCHED</b>   |   |  |
| Minimum documentation searched (classification system followed by classification symbols)   |   |  |
| CIP <sup>6</sup> C07C, C09B, A23L, A23K   |   |  |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched   |   |  |
| Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  |   |  |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>   |   |  |
| Category*   | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No.  |
| X   | Zsako, J. et al; Molecular structure and monolayer properties; Rev. Roum. Chim.32(8), 739-48(1987)<br>Page. 741, Table 1  | 23-24,26   |
| X   | Chifu, Emil et al; Xanthophyll films. I. Single-component monolayers at the air/water interface; J.Colloid Interface Sci. 95(2), 346-54 (1983)<br>Figure.1, 3 and 5; Tablas I and III. Abstract       | 23-24,26   |
| X   | John, Jacob et al; Preparation and properties of hydroxy apocarotenals obtained from Zeaxanthin; Int. J. Vitam. Nutr. Res. 43(1), 70-80(1973)<br>Page. 72, Lines. 7-10                                | 23-24,26   |
| X   | Khachik, Frederick et al; Isolation, structural elucidation, and partial synthesis of lutein dehydration products in extracts from human plasma; J. Chromatogr. B: Biomed. Appl. 670(2), 219-33(1995) | 23-24,26   |
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| Date of the actual completion of the international search<br>9 March 1999 (09.03.1999)  |   | Date of mailing of the international search report<br>12 March 1999 (12.03.99) |
| Name and mailing address of the ISA/<br><br>S.P.T.O<br>Facsimile No.  |   | Authorized officer<br><br><br>Telephone No.                                    |

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International application No.

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| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |  |                       |
|---|--|-----------------------|
| Category*   | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
| X   | Partali, Vassilia et al; Enzymatic Resolution of Zeaxanthin; Biocatalysis, vol.6, p.145-149, 1992  | 23-24,26              |
| Y   | Base de datos WPI en Derwent, semana 9617, Londres: Derwent Publications Ltd., AN-96-167352, JP-08048895 A (ESPIONOSA SANCHEZ R R). Abstract | 1-6,10-13,20          |
| Y   | MORRISON AND BOYD. Organic Chemistry, 3rd Edition, Chapter 20.10, p.669, Example(c), 1973  | 1-6,10-13,20          |
| A   | WO 96/02594 A (INDUSTRIAL ORGANICA S.A. de C.V) 01.02.96. See the whole document   | 1                     |

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